System Functions and Requirements Document
for
The BNL Center for Functional Nanomaterials

At
Brookhaven National Laboratory
Upton, New York 11973

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for
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1.0 PROJECT MISSION

The mission of the Center for Functional Nanomaterials (CFN) is to provide a user facility to understand the chemical and physical response of nanomaterials, with the challenge being to attain the level of understanding needed to tailor or design new classes of functional materials. The CFN's programs will exploit the unique electronic and optical properties of nanoparticles and molecular nanoarrays to design chemical systems with specific functionality for diverse, energy-related applications such as catalysis, photo-induced energy conversion and storage, and molecular conductors.

2.0 INTRODUCTION

Brookhaven National Laboratory (BNL), with extensive input from the academic community, will establish a highly collaborative and multidisciplinary CFN that will provide a unique resource for nanoscale science research.

The CFN will serve as the nucleus of an integrated BNL program in nanoscience. It will facilitate major new directions in BNL's materials and chemical research programs, and greatly expand the capabilities available to a national user base, thereby increasing our university and industrial interactions. It will also enable BNL to promote complementary and interdisciplinary research in the various Departments including Biology, Chemistry, Materials Science, Condensed Matter Physics, Instrumentation Division, and the National Synchrotron Light Source. The CFN will also integrate BNL's unique capabilities in a broad range of synchrotron techniques, including hard and soft x-ray scattering and spectroscopy, with new materials synthesis and nanofabrication capabilities at BNL. The CFN will serve as a focal point for collaborations, enabling studies of functional materials at the nanoscale involving academia and private industry, particularly in the Northeast, thereby catalyzing a new approach to materials research at BNL.

3.0 SYSTEM DESCRIPTION

The CFN facility will be a two-story building of approximately 94,500 square feet, housing clean rooms, wet and dry laboratories, office space for CFN staff and users, and conference rooms. The building will incorporate human factors into its design so as to encourage peer interactions and collaborative visits between BNL staff and users. In addition to offices and laboratories, it will house "interaction areas" for informal discussions on each floor to foster scientific discourse. This design approach is commonly regarded as the state-of-the-art in research facility design. Material and system selections will address the principles of sustainable design to insure low energy and maintenance costs over the life of the building. Design features will be incorporated into the building design that account for the sensitivity of nanoscience instrumentation, i.e., vibration isolation, temperature controls as precise as +/- 0.1 C degrees and shielding from electromagnetic interference.

The CFN will operate through major laboratory clusters: including facilities for nanopatterning fabrication, ultrafast optical sources, electron microscopy, materials synthesis, proximal probes surface characterization, theory and computation, and an endstation at an NSLS beamline optimized for nanoscale characterization using small angle scattering. An initial set of scientific equipment for these laboratories will be purchased as part of the project. The NSLS provides a wide range of imaging, spectroscopy, and diffraction/scattering techniques. In order to take advantage of these features, including the NSLS endstation, the CFN Users will have assured access to a suite of existing beamlines at the NSLS including: soft x-ray microscopy beamlines; UV, soft and hard x-ray spectroscopy beamlines; soft and hard x-ray scattering beamlines; an infrared spectro-microscopy beamline; an undulator insertion device microprobe beamline; and an undulator insertion device nanoprobe beamline.

The CFN will be a new building, located across the street from the existing NSLS. Siting of the CFN will take advantage of close proximity to the Instrumentation Division (Building 535), and the Departments of Physics (Building 510), Materials Science (Building 480), and NSLS (Building 725), which are key interdisciplinary participants in nanoscience research.

4.0 SYSTEM REQUIREMENTS

The CFN will be designed and constructed to provide for flexibility, versatility, durability, and longevity. The interior of the facility shall facilitate dynamic changes in the scientific programs associated with the CFN and shall require minimal modification and relocation to accommodate new programs and staff. Construction materials and technology shall be used that will provide structures and systems with a lifetime of thirty years without major renovation.

Sustainable building design principles shall be evaluated and cost effective features applied to the design and construction of the CFN. Standard practices, which include using recycled content products, purchasing energy efficient and water efficient material and equipment (Energy Star) and substituting less hazardous construction materials shall be used where economically feasible.

The Architect/Engineer shall register the project with the U.S. Green Building Council and submit documentation for a Leadership in Energy & Environmental Design (LEED) certification. Refer to the Appendices of the 100% Title I Report which contains information on required documentation for six (6) prerequisites and nineteen (19) credits which shall be included as a minimum in the CFN design.

The following is an abbreviated Basis of Design for the BNL Center for Functional Nanomaterials. For the complete Basis of Design Narrative refer to the 100% Title I Report submittal by HDR dated February 20, 2004.

4.1 Architectural

A. DESIGN CRITERIA

The facility design will be in accordance with the following codes and guidelines as described within.

1. Building Code of New York State (NYIBC), 2002 Edition
2. ANSI 117.1 - 17.1 Elevator Safety Code, Latest Edition
3. NIH Laboratory Planning and Programmatic Guidelines
4. American with Disabilities Act (ADA) Accessibility Guideline (ADAAG) and ICC/ANSI 117.1 - 117.1
5. National Fire Prevention Code (NFPA) 45
6. Energy Code of New York State
7. DOE order O 413.3.
8. Leadership in Energy and Environmental Design (LEED) 2.1
9. LEED for Labs

B. LABORATORY DESIGN

Requirements of the laboratory space drive both architectural form of the Center for Functional Nanomaterials and the organization of the facility as a whole. The facility incorporates lab-planning concepts:

- Modular lab-planning
- Hierarchical zoning
- Segregation of System in a Service Galley
- Provision to upgrade lab quality in the future

Laboratory Modules

Laboratory space in the Center for Functional Nanomaterials (CFN) must provide for a flexible, adaptable, safe environment for the individual researcher while at the same time be sensitive to changing research and program requirements. The Center's laboratory design must encourage generic space with the ability to readily accommodate changes in function within the same spatial constraints without requiring significant physical or infrastructural modifications.

Since the Center for Functional Nanomaterials integrates several scientific disciplines with their specific laboratory design requirements into a single facility, it is necessary to establish a common spatial denominator to meet a variety of research needs while allowing partitions, equipment, casework and mechanical/electrical/plumbing (MEP) systems to be inserted where required. To achieve this, laboratory space must be planned on a modular basis. The laboratory-planning module becomes the basic conceptual building block that provides regularity and repetitiveness of area and systems for the current and future needs of a facility. It is critical that the module be properly sized so that larger and smaller functional units can be accommodated allowing for the rational configuration of a variety of lab and lab support functions.

After, review of the Conceptual Design Report, extensive interviews with the Laboratory Cluster representatives and tours of existing BNL research facilities, two laboratory-planning modules were developed. The standard lab-planning module, 11’-6” wide x 30’-0” long and nominally 345 square feet, is utilized in the majority of Laboratory Clusters with the exception of the Nanopatterning Cluster (Cleanroom areas). The Cleanroom lab-planning module, 10’-6” wide x 30’-0” long and nominally 315 square feet, is utilized in the Nanopatterning Cluster areas only.

Both laboratory-planning modules are used to create larger lab units by the assembling of multiple modules or smaller lab units by the subdividing of a module. Thus permitting the rational creation of space and the standardization of MEP systems within the lab. MEP systems will be accessible to each individual lab module and designed to be simply extended or adjusted without disruption of research in adjacent laboratory space.

The laboratory modules in the Center for Functional Nanomaterials are organized in five blocks representing five of six Laboratory Clusters consisting of 52 standard modules and 10 cleanroom modules. A listing of Clusters and the number of laboratory modules assigned to each are as follows:

Laboratory Cluster	Assigned Modules
Electron Microscopy	13.5 (Standard)
Material Synthesis	17 (Standard)
Proximal Probes	11.5 (Standard)
Ultra-Fast Optical Source	10 (Standard)
Nanopatterning	10 (Cleanroom)
Theory and Computation	***

**** Theory and Computation Cluster will not be located in Laboratory Standard Module, but will be located on the Second Floor in the office area of the facility.*

Hierarchical Zoning

Lab blocks in the CFN are zoned within the building according to the degree of sensitivity to noise, vibration, temperature, humidity, air quality and/or EMI/ELF. Sensitive research are placed in internal zones buffer from negative influences by simple solutions such as distance or more aggressive solutions as passive ELF shielding.

Service Galleys

In the proposed design of the Center for Functional Nanomaterials (CFN) a Service Galley bisects four of the laboratory blocks and parallels the fifth block. The Service Galley contains the laboratory's main supply and exhaust air distribution; main piped utility distribution, and electrical branch circuit panelboards. These systems will be distributed in a modular fashion readily accessible to accommodate future change, routine maintenance and repair of laboratory services without major interruption of the day-to-day laboratory operations.

In addition, each galley will provide two 3'-0" wide zones of floor area designated to accommodate ancillary laboratory support equipment, which are noise, vibration, heat and/or EMI/ELF generators required to be remote from the sensitive research being preformed. The slab of the galley will be isolated from the slab of the laboratories to make the segregation of vibration generating equipment more effective.

The service galley will be divided into at least three horizontal distribution zones. The upper zone will contain the main HVAC supply and exhaust air ductwork that services the laboratories. Two-snorkel exhaust equipment connection, approximately 150 CFM each, will be provided at 23'-0" o.c. on both sides of the galley to serve ancillary equipment which are heat and/or exhaust sources.

The middle zone will contain the main piped utility distribution for the laboratories. Piping is arranged horizontally on unistrut trapezes with capped terminations at 11'-6" o.c. on both sides of the galley providing the capability of entering the labs at ceiling level to serve research equipment located in the middle of the laboratory module or rolling down the wall to enter the piped utilities chase behind the laboratory casework. The following piped utilities will be distributed in galley: Lab Hot and Cold Water, Lab Vacuum, Lab Compressed Air, Tempered Water and Process Cooling Water Supply and Return.

Laboratory electrical distribution will occupy the lower zone. One 50 amp sensitive power panelboard and one 100 amp non-sensitive power panelboard will be provided at 23'-0" o.c. on both side of the galley to serve every two lab modules. From the panels non-sensitive will be distributed in raceway horizontally along the galley walls. Sensitive and non-sensitive power will have capability of entering the labs at ceiling level to serve research equipment located in the middle of the laboratory module and entering at lab bench top level to be distributed by raceway.

Flexibility and Upgradeability

The CFN is designed with provisions to accommodate the future. All typical laboratory features will have built-in flexibility that enhances the ability to upgrade. Corridors and entrances to the laboratories will be oversized to allow the maneuvering of large pieces of laboratory equipment.

Lab piped service will be designed with spare capacity to accommodate growth. Capped connections in the piped system will be provided on a modular frequency to allow expansion of a system into any laboratory with minimal disruption of service. Zones in piping carriers will be designated for future expansion to provide pathway for addition of new distribution system for services not installed in the original facility scope.

Spare circuiting capability will be provided in lab sensitive and non-sensitive electrical panels to allow for future expansion. Zones will be designated in the penthouse for the future installation of transformers to accommodate the next generation of laboratory equipment power requirements.

These are some of the features that will be initially built-in to the facility to address the issues of flexibility and adaptability in the ever-changing field of Nano research.

4.2 Structural

A. BUILDING DESCRIPTION

The proposed Center for Functional Nanomaterials (CFN) shall be predominantly a two-story steel framed building with laboratories, offices and clean room on Ground Level and mechanical penthouse and additional offices on Upper Level.

B. DESIGN CRITERIA

The structural design will be in accordance with the following codes, guidelines and loads as described within.

1. Codes and Guidelines:

   - Building Code of New York State
   - ACI 318-99, Building Code Requirements for Structural Concrete
   - AISC Manual of Steel Construction (ASD), Ninth Edition

2. Live Loads:

   - Laboratories: 125 psf
   - Corridors: 100 psf
   - Stairs and Lobbies: 100 psf
   - Offices: 100 psf (incl. 20 psf for partitions)
   - Light Storage Areas: 125 psf
   - Mechanical Rooms: 150 psf or actual weight of equipment

3. Snow Loads:

   - Ground snow load Pg: 45 psf
   - Snow importance factor I: 1.0
   - Snow exposure factor Ce: 0.9
   - Thermal Factor Ct: 1.0
   - Design snow load: 30 psf + drift where applicable

4. Wind Loads:

   - Basic wind speed (3-second gust): 120 mph
   - Wind load importance factor: 1.00
   - Wind exposure: B

C. CONSTRUCTION

1. Foundation:

   The geotechnical investigation of the site for this project is under way and based on some preliminary information available, it is anticipated that foundation system for the proposed building shall be spread footings with an allowable bearing pressure around 2000psf.

2. Ground Floor Slab:

   Typically this will be a 6" thick slab on grade reinforced with 6 x 6 - W2.9 x W2.9 WWF over 6" compacted granular fill and vapor barrier.

However, slabs on grade in the laboratories and service galley shall be 12” thick as governed by vibration criteria.

3. Upper Level Floor:

   The floor at this level shall typically consist of 20 GA - 2” thick composite steel deck with 3” lightweight concrete topping (total slab thickness: 5”) supported on framework of steel beams and girders. See Sketch SK-S01 in the Appendix for floor framing of a typical interior bay.

4. Roof:

   The roof will consist of structural steel framing supporting 20 GA - 1-1/2" thick steel roof deck. See Sketch SK-S02 in the Appendix for roof framing of a typical interior bay. Use of steel beams instead of open web steel joists will afford a lot more flexibility for supporting mechanical ductwork and piping. Shallower steel beams in lieu of deeper steel joists will also provide more clearance from hanging ductwork, piping and equipment.

D. LATERAL LOADS RESISTING SYSTEM

Lateral loads shall be mainly resisted by braced frames wherever possible, otherwise by moment frames where bracing location would become architecturally prohibitive.

E. MATERIALS

1. Concrete (normal weight):

   Foundation and slab on grade: f'c = 4000 psi.
   Piers, walls, grade beams and stairs on grade: f'c = 4000 psi.
   Light weight concrete for Upper Level Floor: f'c = 4000 psi.

2. Reinforcing steel:

   Deformed: ASTM 615, Grade 60.
   Welded wire fabric: ASTM A185.

3. Structural steel:

Wide flanges and tees: ASTM A992, Fy = 50 ksi.
Channels, angles and plates: ASTM A36, Fy = 36 ksi.
Steel pipes: ASTM A53, Type E or S, Grade B, Fy = 35 ksi.
Structural tubes: ASTM A500, Grade B, Fy = 46 ksi.
Anchor bolts: ASTM A307, 3/4" dia. min.
Bolts: ASTM A325, 7/8" dia. min.

4. Masonry:

Hollow light weight CMU: ASTM C90, Grade N-1, f'm = 1500 psi, f'c = 2000 psi (min.).
Mortar: ASTM C270, Type S, f'c=1800 psi.
Grout for CMU walls: f'c = 2000 psi (min.)

4.3 Vibration Control and Acoustics

A. GENERAL

1. Goals

The vibration control design will interface with the design of structural, mechanical, architectural and electrical systems in such a way that those systems do not generate or propagate vibrations detrimental to current or future research activities of the Center for Nanoscale Materials. Research using vibration-sensitive equipment impose very stringent vibration requirements upon these systems.

B. VIBRATION CRITERIA

1. Vibration Criteria

Vibration criteria have been developed based upon interviews with users and examination of vibration requirements of planned or hypothetical equipment. They are stated as six vibration amplitude functions given in terms of one-third octave band root-mean-square (rms) velocity spectra. Four of them are based upon popular generic vibration criteria published by the Institute of Environmental Sciences and Technology (IEST);[1] the fifth and sixth were developed for the Advanced Measurements Laboratory (AML) being constructed at NIST in Gaithersburg, MD. The following table summarizes the criteria and their areas of application.

[1] Institute of Environmental Sciences, "Considerations in Clean Room Design," *IES-RP-CC012.1* (1993)

Space Category	Criterion, μin/s	Source
General Labs	2000-4000	Industry Practice
Class 1000 Cleanrooms	1000	VC-B (IEST)
Class 100 Cleanrooms	250	VC-D (IEST)
Class 10 Cleanrooms	125	VC-E (IEST)
Metrology; Surface Characterization	125 – 250	VC-D to VC-E (IEST)
Nanostructures AFM / "Atom Pushing"	125	VC-E (IEST) or NIST-A
Nanostructures Instrument Development	< 50	NIST-A1

Criterion Type NIST-A1: rms velocity amplitude of 3 micrometer/sec (125 microinch/sec) at frequencies below 4 Hz; rms velocity amplitude of 0.75 micrometer/sec (30 microinch/sec) at frequencies between 4 Hz and 100 Hz.

Criterion NIST-Type A: rms displacement amplitude of 0.025 micrometer (0.025 μm, or 1 microinch) at frequencies between 1 and 20 Hz; rms velocity amplitude of 3 micrometer/sec (125 microinch/sec) at frequencies above between 20 Hz and 100 Hz.

IEST Criteria: rms velocity amplitude of xxx microinches/sec at frequencies between 1 Hz and 80 Hz, where xxx takes on the values of 2000, 1000, 500, 250 and 125, for curves VC-A through VC-E, respectively. This uses the newer interpretation of the IEST criteria, in that the requirements remain constant down to a frequency of 1 Hz, rather than being relaxed at frequencies less than 8 Hz. This interpretation has been put forward to address the needs of pneumatically vibration-isolated equipment.

2. Review of User Needs

The specific vibration and acoustic requirements of individual users were solicited via in-person interviews. In addition to meeting the immediate and anticipated needs of current users, it is important to anticipate needs of future researchers and future work at the facility. The following figure lists the vibration requirements of a collection of equipment of the sort that might be used, showing the range of published vibration sensitivity. The constant-amplitude version of VC-E lies below all of these requirements at frequencies above 10 Hz; NIST-A lies below all the curves at all frequencies above 1 Hz.

4.4 Mechanical – HVAC Systems

A. DESIGN CRITERIA

The design of the heating, ventilating and air conditioning system will be in conformance with the design guidelines of the following applicable codes and guidelines.

1. Mechanical Code of New York State
2. Energy Conservation Construction Code of New York State
3. American Society of Heating, Refrigerating, and Air Conditioning Engineers Design Guidelines
4. ASHRAE Standard 90.1-2001 Energy Standard for Buildings Except Low-Rise Residential Buildings
5. ANSI/ASHRAE Standard 62-2001 Ventilation for Acceptable Indoor Air Quality
6. Sheet Metal and Air Conditioning Contractors' National Association Standards for Ductwork Design
7. National Fire Protection Association Standards
8. ANSI/AIHA Z9.5-1992 - Standards for Laboratory Ventilation
9. ANSI/ASHRAE 110-1985 Method of Testing Performance of Laboratory Fume Hoods
10. Authorities having jurisdiction

B. DESIGN CONDITIONS

1. Outdoor:

Summer - 95 °F dry bulb,
76 °F wet bulb

Winter - 0 °F, 15 mph wind

2. Indoor:

Area Designation	Design Temperature °F		Accuracy ±°F	Relative Humidity %	
	Winter	Summer		Winter	Summer
Clean Rooms	68	68	2	50	50
Ultra-Fast Optical	70	70	0.5	30	50
Materials Synthesis	70	70	2	30	50
Proximal Probes	70	70	0.5	30	50
Electron Microscopy SEM	70	70	0.18	50	50
Electron Microscopy TEM	70	70	2	30	50
Electron Microscopy	70	70	0.5	30	50
Offices	74	70		30	50
Support Facilities	74	70		30	50

* Accuracy ±5%

3. Air Filtration:

Area	Pre-filters	Final Filters
Laboratories	60%*	95%
Clean room make-up air	60%	99.997%

Offices, lobby, support 60%

* Pre-filters will be provided with 30% panel filters upstream

C. UTILITY SYSTEMS

1. Chilled water

Ten-inch supply and return chilled water pipes will be connected from the existing underground site chilled water system to the building. The chilled water temperature supplied by the Central Plant is 46°F. The flow and supply/return water temperature difference will be measured for cooling energy calculations. Estimated cooling load of the building is 1200 tons including 40% additional capacity for future expansion. The total chilled water flow is 2060 GPM using 14 °F temperature rise.

2. Steam

Steam is available at the site from the Central Utility Plant at 125 PSIG. The estimated steam load of the new building is 12600 lbs/hr including 40% future capacity. The estimated size of the underground steam supply conduit is 6 IN. The condensate will be in a separate conduit using a 2-1/2 IN schedule 80 carrier pipe. Steam flow will be measured for energy calculations.

D. HVAC SYSTEMS

1. General Laboratories

In laboratories, minimum 15 air changes per hour will be used. This airflow provides 2.5 CFM/SQFT and it is based on 10 FT ceiling height. Assuming no external heat gain, 3 W/SQFT for lighting, and 165 SQFT/person for people load, this design will allow 10 W/SQFT miscellaneous heat gain from equipment. After the equipment heat gain and the number of fume hoods are further defined, the supply and exhaust air requirement of the laboratories will be finalized. For laboratories with temperature control accuracy of ±0.5 °F, we recommend 20 air changes per hour.

2. High Accuracy Laboratories

Two Electron Microscopy (SEM) laboratories, one of which will be built in future, require ±0.1 °C accurate temperature control. In order to assure such high precision, each of the rooms will have its own air handling unit supplying 120 air changes per hour. Air will be distributed vertically from a ceiling plenum through HEPA filters. Air will return through low wall grilles and wall plenums that completely surround the space. This will assure the required thermal isolation. In order to provide the lowest possible noise and vibration in the space, the air velocity in the branch ducts will be kept below 600 FPM. Prior to entering the plenum, the velocity will be reduced to 300 FPM.

The air-handling unit serving the high accuracy space will include 60% prefilter, cooling coil, supply fan, silencer, and 95% final filter. The supply fans will have Adjustable Frequency Drives (AFD), allowing airflow reduction to minimize vibration caused by the high air flow. Air leaving the units will be cooled 0.5 °C below the required room temperature, and electric reheat coils responding to duct sensors in the branch ducts will reheat the air to the required discharge air temperature to maintain the ±0.1°C accuracy. Room temperature sensors will reset the duct sensor to maintain the room temperature. SCR's using high accuracy controllers will control the electric reheat coil.

In order to provide the necessary ventilation air, pressurization and individual humidity control, the circulating air handling units will be provided with one common make-up air unit. This unit will supply a minimum of 6 air changes per hour to each of the high accuracy laboratories. The unit will include 60% prefilter, glycol preheat coil, cooling coil, supply fan, reheat coil, 95% final filter and a primary humidifier. Individual room humidity control will be by secondary humidifiers located in the branch ducts.

For high accuracy temperature control design concepts, see Figures 1 through 3 in the Appendix.

3. Clean Rooms

The air-handling units for the various clean room areas will be sized using the following criteria:

Area	**Class**	**Velocity FPM**	**AC/HR***
E-Beam	100	55	330
Prep/Optical Lithography	100	55	330
Analytical	1000	25	150
Plasma/Etching	1000	25	150
Thermal Evap/Sputtering	1000	25	150
Clean corridor	1000	25	150
Gowning, Vestibule	10,000	15	90
Service Galley	100,000	4	24

* Based on 10 foot ceiling height

Circulating units will be located in the penthouse above the clean rooms. Air will be ducted to individual HEPA filters located in the ceiling of each area. Air will return through wall cavities and open plenums above the clean rooms. Multiple units serving each area will provide redundancy. Air handling units serving each area will be separated to prevent cross contamination. Circulating units will include 30% prefilter, cooling coils, supply fan, and discharge silencer. Return silencers will be located below the equipment room floor. One make up air unit will be provided for the clean areas. It will be sized for the exhaust requirements and for air required for pressurization. The makeup-air unit will have pre-filters, preheat coil, cooling coil, supply fan, and final filters. Secondary humidifiers located in the branch ducts serving the different air-handling units will control the individual space humidity. See Figure 4 in the Appendix for clean room air distribution concept.

E. AIR HANDLING SYSTEMS

Air handling units serving laboratories will be 100% outside air, constant volume terminal reheat type. Variable volume terminal reheat air handling units will serve offices, conference rooms, and other non-critical areas. A separate variable volume air-handling unit will serve the lobby to provide building pressurization. The clean rooms will be served by several clean room type air-handling units to provide the required cleanliness. The Electron Microscopy rooms will have their own circulating air handler supplying 120 air changes per hour to assure ±0.1 °C accurate temperature control. Both, the high accuracy temperature controlled labs and the clean room units, will have their own make up air units. Air handling units will be located in penthouses above the laboratories and clean rooms.

1. Unit Construction

Air handling units will be custom designed, factory assembled, and industrial grade type. They will have 4-inch double wall construction, stainless steel interior liner, and stainless steel condensate drain pan.

Laboratory units will have 60% pre-filter, heat recovery coil, glycol water preheat coil, chilled water cooling coil, supply fan, sound attenuator, 95% final filter, and humidifier. Air handling units serving administrative areas and the lobby will have return fan, relief air section, mixing section, 60 % prefilter, glycol preheat coil, cooling coil, centrifugal fan, sound attenuators, and humidifier.

The make up air unit for the high accuracy laboratories will be factory package type. It will be 2-inch double wall construction with components similar to units serving the laboratories. All air-handling units will have access sections between the various components which allow efficient airflow through the units and adequate space to perform maintenance and inspection. All units will be installed in draw through configuration providing good dehumidification and even air flow through the cooling coil.

Supply and return fans will be centrifugal, belt-driven and will have high efficiency airfoil blades and AMCA label. They will be dynamically balanced after installation on the job site. Air pre-filters and final filters will be replaceable cartridge type with filter efficiencies based on NBS Atmospheric Dust Spot Method. Their sizes will be standardized 24 x 24 and 12 x 24 IN where possible. Supply and return fans of all air handling units will have AFD's for future flexibility and to provide ease of adjustment during balancing. Energy efficient electric motors will be compatible with AFD's. For typical air handling unit design, see Figures 5 through 10 in the Appendix.

F. AIR DISTRIBUTION

1. Ductwork

All ductwork will be constructed in accordance with SMACNA standards. Supply air ducts will be galvanized steel, and be insulated on the exterior. High-pressure duct upstream of the terminal units will be built to 10 IN WG pressure and will be sized for medium velocity. Gauges of ducts will be increased to minimize duct generated noise vibration. Low-pressure ducts constructed to 2 IN WG will be used from terminal units to diffusers. Flexible run outs to diffusers will allow ease of installation and provide final sound attenuation of terminal unit and duct-generated noise. Exhaust and return ductwork will be low and medium pressure construction sized for 0.075 IN WG/ 100 FT friction loss and/or 1800 FPM velocity maximum. They will be un-insulated except in areas where condensation on duct surfaces may occur. In supply ducts, no internal lining will be used. Welded stainless steel will be used for all lab exhaust. Return air from all areas will be ducted.

2. Air Terminal Units

Space temperature control will by constant and variable volume terminal units with reheat coils. Heating coils will have copper tubes with bonded aluminum fins. Individual terminal units will be provided for each laboratory, and other areas requiring individual temperature control. Offices with similar thermal load, maximum four, may be served by one terminal unit.

3. Diffusers, Registers and Grilles

Four-way, louvered faced supply diffusers and perforated face return and exhaust registers will be used in laboratories and administrative offices.
In noise and vibration sensitive areas, high volume diffusers will be considered. Air distribution devices in large open areas will be compatible with the architectural design. All devices will be sized to provide good air distribution and maximum noise criteria of NC 30.

4. Pressurization

A negative pressurization of 100 CFM per door will be maintained in the laboratories by exhausting more air from the rooms than supplied. Clean rooms will be positively pressurized by 100 CFM per door.

In toilets, janitor closets, and other less critical areas, negative pressurization will be maintained at 50 CFM per door. In the clean rooms, the positive pressurization airflow will be 0.5 CFM/SQFT. The entire building will be kept at positive pressure.

G. EXHAUST SYSTEMS

1. Exhaust fans

Exhaust fans will be provided for the following:

a) Fume hoods

b) General laboratory exhaust

c) Toilet rooms

d) Mechanical and electrical rooms

e) Process equipment

f) Hazardous storage

g) Other areas requiring exhaust

2. Laboratories

Laboratories will be provided with independent exhaust systems. For flexibility, cost effectiveness, and for allowing heat recovery and stand-by capability, laboratories will have central exhaust fans. Risers will be connected to an exhaust manifold in the penthouse. Hood exhaust branches and general exhaust ducts will have flow control devices to minimize balancing requirements during future changes. Exhaust fans of laboratories will discharge the air at high velocity to prevent re-circulation. For redundancy, stand-by lab exhaust fans will be provided. See Figure 11 in the Appendix for lab exhaust system concept.

H. STEAM DISTRIBUTION SYSTEM

The high pressure steam will be reduced inside the building to 30 PSIG and 15 PSIG. 15 PSIG steam will be used for general purposes such as heat exchangers, domestic water heaters, humidifiers, and other miscellaneous heating devices while 30 PSIG steam will be supplied to the clean steam generators to minimize their size. All steam condensate will be returned to the Central Plant. The steam distribution system will be sized for present and future loads. See Figure 12 in the Appendix for steam distribution concepts.

I. HEATING HOT WATER AND GLYCOL SYSTEMS

Water will be heated in steam fired heat exchangers and will be used for terminal reheat coils and in miscellaneous heating devices such as fan coil units, unit heaters, and finned tube radiation. A second system, utilizing a 40% propylene glycol solution, will be used for preheat coils.

Duplex heat exchangers will be sized for 100% of the heating load for redundancy, while redundant circulating pumps will each be sized for 66% of the full flow. Control valves will be two-way type; except three-way valves will be used at the end of long runs to assure adequate system circulation and minimum 25% flow through the circulating pumps. Isolation valves will be provided at riser connections and piping will be designed in a reverse return configuration to simplify balancing. See Figure 13 and 14 in the Appendix for Typical Heating System Schematics

J. CHILLED WATER SYSTEM

The pumps at the central plant have adequate capacity to serve the building. Consequently, no main building chilled water pumps will be provided. Cooling coils will be selected to minimum 14 °F temperature difference. Pumping configuration and controls will maintain 60°F return water temperature. Two-way control valves will be used on the air handling unit chilled water coils to achieve flow reduction at low loads. The extension of the site distribution will be sized for the future addition. In clean room circulating air handlers and for units serving the high accuracy laboratories, a secondary chilled water system with 55°F discharge water temperature will provide the necessary sensible cooling.

K. HUMIDIFICATION

For humidification, steam from the central plant will be utilized. Primary humidifiers in the air handling units and secondary ones located in the make up air ducts of the various clean rooms and high accuracy room air-handling unit will maintain the required humidity levels. Multiple manifold stainless steel humidifiers will be located downstream of final filters and will be selected to minimize vapor trail. Humidity sensors will be located in general lab exhaust systems, return air ducts, and the various laboratories. For the clean rooms, clean steam will be provided by two steam to steam generators, each sized for 100 % of the load.

L. PIPING SYSTEMS

Piping will be schedule 40 black steel with screwed joints through 2-inches and welded joints 2-1/2 inches and up. Schedule 80 black steel will be utilized for condensate return pipe to provide a longer life. Pipe will be provided with fiberglass pipe insulation with all-service jacket and self-sealing lap. Hydronic piping systems will be sized for a maximum velocity of 8 feet per second, and a maximum pressure drop of 4 FT per 100 FT. In noise and vibration sensitive areas, velocity will be limited to 4 feet per second. Chilled water piping insulation will be provided with vapor barrier jacket to prevent condensation. In-line circulators will be used for pumps under 1/2 HP. Pumps 1/2 HP and larger will be base mounted end suction or vertical/horizontal split case type. Motors 3 HP and over will be premium efficiency. Strainers, check valves, and temperature and pressure gauges, water treatment system, air and pressure control will be provided. Clean steam supply and condensate return pipes will be stainless steel.

M. MISCELLANEOUS HEATING/COOLING DEVICES

Fan coil units will be provided in stairways and lobbies for heating, cooling, and humidity control. Unit heaters will be used in mechanical and electrical equipment rooms. Finned tube radiation will be used to offset the “cold wall” effect of exterior walls and windows in offices and other areas.

N. ENERGY CONSERVATION

In order to minimize the building’s energy consumption and comply with the LEED certification criteria, various energy conservation techniques will be used or further evaluated during the design.

1. Energy Saving Measures

In order to minimize the building’s energy consumption, for the laboratory and clean room make up air handling units coil loop heat recovery will be provided. The filters and heat recovery coil will be bypassed during non recovery periods to minimize exhaust fan energy.

Discharge temperature of heating hot water will be reset during the summer to minimize heat loss.

AFD's will be used for all major air moving devices and pumps.

High efficiency equipment and high efficiency motors will be selected for all applications.

Non-critical air handling units will operate utilizing optimum start stop energy management software.

Insulation of piping system will exceed the applicable energy codes.

O. AUTOMATIC TEMPERATURE CONTROL

Direct digital controls, compatible with the existing Building Automation System, will be utilized. In order to assure full compatibility, control system will be provided by Automated Logic Corporation. Except for air terminal units, control valves and dampers will have pneumatic actuators. A duplex control air compressor, air dryer, and filter will be installed in the lower level mechanical room.

Air handling units with return fans will have airside economizer, which allows the utilization of 100% outside air for free cooling. A signal from the fire alarm system or smoke detectors in the ducts will initiate an automatic smoke evacuation. During this mode, air-handling units with return fans will operate in 100% outside air mode. All return air will be exhausted from the building. 100% outside air units will continue to operate. As an option, in case of smoke detection, all air-handling units will shut down. The fire fighters then may initiate smoke evacuation manually. See Figures 14 and 16 in the Appendix for typical air handling unit control schematics.

P. SYSTEM TESTING AND BALANCING

1. Waterside

   System will be leak tested, and pumps and other equipment will be checked for alignment and proper operation. Flow through pumps will be measured and properly adjusted. Motor amperage will be read and recorded.

2. Air Side

   High-pressure supply ducts and all hood exhaust duct systems will be tested for leaks. System fans will be checked for proper rotation and balance, and all drive sheaves will be adjusted for proper airflow.

Motor amperage will be read and recorded. Airflow at all terminal units, diffusers, registers, and grilles will be adjusted to specifications and recorded.

3. Commissioning

Due to the size and complexity of the project and in compliance with LEED requirements, a full commissioning will be included.

4.5 Mechanical – Plumbing Systems

A. DESIGN CRITERIA

The design of the plumbing system will be in conformance with the design guidelines of the following applicable standards and codes.

1. Plumbing Code of New York State (May 2002 edition)

2. Building Code of New York State (May 2002 edition)

3. Energy Conservation Construction Code of New York State (May 2002 edition)

4. All applicable local codes and Authorities Having Jurisdiction (AHJ)

B. DOMESTIC (POTABLE) WATER SYSTEM

Domestic water serving the facility provides the basis for the domestic and laboratory water systems. An estimated 3-inch water service will be extended from the site water main. The available pressure is estimated at 60 PSI. The inclusion of filters, and a reduced pressure backflow prevention device in the service results in insufficient pressure for operation of the systems. Therefore, a triplex booster pumping system will be provided. A water meter will be installed in the service entry room.

Once inside the building, the service will divide into two branches, consisting of a domestic branch serving general purpose plumbing fixtures and emergency fixtures, and a laboratory branch serving the laboratory fixtures and equipment. A reduced pressure backflow prevention device will be installed in the laboratory branch (See Laboratory Water System discussion).

Domestic hot water will be provided and includes a circulated piping system. Hot water will be produced by a storage type hot water generator utilizing steam as the heating medium. The estimated capacity is 400 gallon nominal storage and 400 gallon per hour recovery from 40 degF to 140 degF. Example: RECO RV368 vertical tank with nominal storage capacity of 395 gallons, and double wall coil using 350 lb/hr steam at 15 PSIG.

A tempered (95 degF) water distribution piping system will be provided and used as the source for the emergency fixtures located throughout the facility and for the lavatories in the toilet rooms. The system will be circulated.

Type "L" copper tubing with wrought copper or cast brass fittings and solder joints will be the pipe material. The pipe joints will be formed with 95-5 tin-antimony solder or code approved "lead free" solder and flux having a chemical composition equal to or less than 0.2-percent lead. Piping 2-inch and smaller may be joined with fittings utilizing a copper crimping system such as the Rigid/Viega ProPress System. Three (3) inch piping may be schedule 40 galvanized steel with threaded or mechanical couplings (Victaulic style connections). The piping will be insulated with fiberglass pipe insulation having an all service jacket and self-sealing lap.

C. SANITARY DRAINAGE AND VENT SYSTEM

The building sanitary system will provide drainage facilities for the toilet fixtures, and mechanical room drains.

Horizontal collection into the building drain will occur below the lowest floor slab and exit by gravity to the site sanitary sewer. Minimum size of below grade piping shall be 3-inch. The building drain is estimated to be 6-inch at the connection with the building sewer.

Cleanouts will be provided per code and as required to assist in proper maintenance of these lines.

Service weight cast iron soil pipe and fittings will be used for sizes 3-inch and larger. Gasketed bell and spigot joints using a neoprene gasket will be used for the portions of the system that will be underground. No-hub clamped joint using a one-piece neoprene gasket, and stainless steel shield with retaining clamps will be used for the above ground portions. For sizes 2-1/2-inch and smaller, piping shall be schedule 40 galvanized steel pipe with cast iron drainage fittings, or Type “L” copper tubing with DWV fittings.

D. STORM (RAIN) WATER DRAINAGE SYSTEM

Storm water will be collected utilizing commercially available drains of style, size, and quantity consistent with the area being drained. The piping will generally be routed vertically from the drains to below the lowest floor slab where it will be collected horizontally and discharge by gravity to the site storm sewer. Where roof scuppers cannot be used, a secondary roof drain system will be provided.

Rain leaders will exit the building in multiple locations on the east and west sides and connect to storm sewer laterals (Refer to Civil documentation).

The system will be sized based on rainfall rate of 3-inches per hour, 100 years, 1 hour storm.

Cleanouts will be provided per code and as required to assist in proper maintenance of these lines.

Service weight cast iron soil pipe and fittings will be used for all sizes. Gasketed bell and spigot joints using a neoprene gasket will be used for the portions of the system that will be underground. No-hub clamped joint using a one-piece neoprene gasket, and stainless steel shield with retaining clamps will be used for the above ground portions.

E. LABORATORY WATER SYSTEM

The laboratory water system supplies the laboratory fixtures and equipment. The laboratory water system is considered non-potable and will be provided with a reduced pressure backflow prevention device to isolate it from the domestic system.

Laboratory hot water will be provided by an instantaneous, feed forward steam water heater with double wall construction. The system will be circulated. The water heater estimated capacity is 20 gallons per minute from 40 degF to 140 degF using 1100 lb/hr steam at 15 PSIG. Example: Armstrong Flo-Rite-Temp Model 535.

The same piping material will be utilized for this system as is being used for the domestic water system. All piping will be insulated.

F. LABORATORY DRAINAGE AND VENT SYSTEM

BNL utilizes a strict protocol of collecting waste chemicals in specific containers for storage and ultimate disposal. To enhance future flexibility, the drain piping from laboratory sinks, hoods, and drains will be designed as a laboratory drainage system consisting of waste and vent piping serving only the laboratories. This system will be extended to outside the building and connected into the building sanitary sewer prior to connection to the site sanitary sewer.

Corrosion resistant, Schedule 80 polypropylene DWV pipe and fittings with socket fusion joints will be used for the under slab portions of the system. The portions of the system above grade will be corrosion resistant, fire retardant, Schedule 40 polypropylene DWV pipe and fittings. Mechanical joints may only be used for above grade piping in exposed or fully accessible locations. Socket fusion joints may be used in all locations.

G. PLUMBING FIXTURES

1. General

The quantity of fixtures will comply with the requirements of the Codes and the functional requirements of the facility. Fixtures suitable for use by the physically handicapped will be provided. The plumbing fixtures and associated trim will incorporate water-conserving features. In the sections that follow, a general description of the fixture is presented followed by an actual example of a manufactured item meeting the criteria. All exposed waste and supply piping will be chrome plated. Escutcheons at waste and supply wall penetrations will be chrome plated cast brass with set-screw.

The fixture descriptions are representative of fixtures that may be used on this project.

2. Standard Water Closet

Vitreous china, wall hung, elongated bowl, siphon jet, water-conserving design, 1 1/2-inch top spud with chrome plated handle-operated exposed flush valve using 1.6 gallons per flush (GPF), open front seat, and wall hung on floor mounted water closet carrier. Mounting height will be 15 inches from lip to finished floor.

Fixture - American Standard Afwall 2257.103
Flush valve - Sloan Royal 115
Seat - Church 295C
Carrier - Wade W-300 series

3. Handicap Accessible Water Closet

Vitreous china, wall hung, elongated bowl, siphon jet, water-conserving design, 1 1/2-inch top spud with chrome plated handle-operated exposed flush valve using 1.6 GPF, open front seat, and wall hung on floor mounted water closet carrier. Mounting height will be 17 inches from lip to finished floor.

Fixture - American Standard Afwall 2257.103
Flush valve - Sloan Royal 111
Seat - Church 295C
Carrier - Wade W-300 series

4. Urinal, Waterless

   Elongated rim, wall hung, waterless, with integral trap liquid seal. Mounted on floor mounted urinal carrier. Mounting height will be 17" from lip to finished floor.

   Fixture – Waterless Co. LLC Sonora 2004
   Carrier - Wade W-400 series

5. Counter Mounted Lavatory

   Type 304 stainless steel, 18 gauge, 18-inches round undermount. Trim will include vandal-resistant centerset (4-inch center) commercial grade chrome plated brass faucet with single handle, chrome plated brass grid drain with 1 1/4-inch tailpiece, 1 1/4-inch by 1 1/2-inch chrome plated brass P trap, 1 1/2-inch chrome plated brass trap nipple, and chrome plated flexible risers with loose key stops. The faucet will be provided with a 0.5 gpm flow restricting device.

   Fixture – Just UCIF-16
   Faucet/Drain – Delta Faucet Co. 503 with grid drain.
   Supplies – Brass Craft Speedway

6. Shower

   Pressure balance mixing valve, adjustable volume control, and variable spray pattern head.

   Fixture - Speakman SM-1407-AF

7. Mop Sink

   Molded stone or terrazzo, 24 x 36 inches one-piece basin, cast-in drain with dome strainer and bumper guards on all exposed sides. Chrome plated brass combination service sink faucet with integral vacuum breaker, 3/4-inch threaded hose end spout, indexed four arm handles, adjustable wall brace, and integral stops.

   Fixture - Fiat MSB-3624
   Faucet - Fiat 830-AA

8. Emergency Shower

   Polished chrome plated cast brass shower head, 8-inch diameter, 1-inch IPS chrome plated brass drop nipple (length as required) with polished chrome plated cast brass set screw escutcheon at ceiling penetration. Concealed 1-inch IPS brass stay open ball valve and stainless steel wall mounted cabinet with heavy duty "panic bar" actuating arm.

Fixture - WaterSaver Faucet Co. ES670.

9. Electric Water Cooler

Self contained refrigerated unit with chrome plated bubbler and self-closing push bars on front and both sides. Handicap accessible, wall hung on floor mounted carrier. Unit will be certified to be "lead free" in accordance with the Safe Drinking Water Act.

Fixture - Halsey Taylor HAC-8FS
P-trap - McGuire 8090
Trap nipple - McGuire 2127
Supplies - McGuire 165LK

10. Floor and Shower Drains

Cast iron body, bottom outlet, clamping collar, seepage flange, and weep holes.

a) Floor Drain (General Purpose)
Light duty with nickel alloy square or round strainer and integral floor level cleanout. Wade W-1120CONH or W-1120CONH-G.

b) Floor Drain (Mechanical Rooms, etc.)
Medium depth sump with heavy duty tractor type grate and integral floor level cleanout. Wade W-1370.

c) Shower Drain
Light duty with nickel alloy square or round strainer. Wade W-1100-G.

11. Roof and Area Drains

a) Roof Drain
Coated cast iron body, large sump, bottom outlet, non-puncturing clamping ring with integral gravel stop, removable mushroom type dome strainer, bearing pan, and underdeck clamp. Wade W-3000-52-53.

b) Area Drain
Wade W-1300-TD

12. Cleanouts

a) Wall Cleanout
Coated cast iron, cleanout tee with taper thread bronze plug, and round or square stainless steel secured access cover. Wade W-8460-R or W-8460-S.

b) Floor Cleanout
Coated cast iron, inside caulk connection with taper thread bronze plug, adjustable housing, and scoriated secured round or square nickel alloy top. Provide clamping ring and flange at waterproof membranes. Wade W-6010-75 or W-6010-S-75.

4.6 Mechanical – Fire Protection Suppression Systems

A. DESIGN CRITERIA

The design of the fire protection suppression systems will be in conformance with the design guidelines of the following applicable standards and codes.

1. Fire Code of New York State (May 2002).

2. Building Code of New York State (May 2002).

3. National Fire Protection Association Standards

   a) No. 13 – Standard for the Installation of Sprinkler Systems (1999)
   b) No. 14 – Standard for the Installation of Standpipe and Hose Systems (2000)
   c) No. 20 – Standard for the Installation of Stationary Pumps for Fire Protection (2003)
   d) No. 45 – Standard on Fire Protection for Laboratories Using Chemicals (2000)
   e) No. 318 – Standard for the Protection of Semiconductor Fabrication Facilities (2002)

4. All applicable state and local codes and Authorities Having Jurisdiction (AHJ).

B. FIRE SERVICE

An 8-inch fire service with post indicator valve will be extended from the site water main. Preliminary data indicates an available pressure of approximately 60 PSI which is marginal for the expected systems. The actual available pressure has not been verified at this time. Fire flow data will be obtained during design to confirm this conclusion.

C. SPRINKLER SYSTEM

The sprinkler system will be designed to provide 100-percent protection of the facility. Where the piping installation will be subject to freezing temperatures such as at the loading dock, a dry sprinkler system will be employed.

Interior piping will be Schedule 40 steel pipe. No other piping material will be acceptable. The piping will be joined by welding, threaded fittings, or roll groove fittings and couplings. Pipe and fittings used in dry pipe portions of the system will be galvanized inside and outside.

Unless otherwise indicated, the entire sprinkler system will be designed as Ordinary Group 1 Hazard occupancy with 0.15 GPM/SF density. The remote hydraulic area will be calculated at 2500 square feet.

The portion of the system serving the cleanroom will be designed with a density of 0.20 GPM/SF over a design area of 3000 square feet per NFPA 318.

D. STANDPIPE SYSTEM

A fire standpipe system is not required for this facility based on the Building and Fire Codes of New York State.

If a standpipe system is desired by the Owner, it is recommended that a manual wet Class I standpipe system be installed in the stair towers with 2-1/2-inch fire department valves having 2-1/2-inch by 1-1/2-inch reducers. Additional standpipes and fire department valves may be located as required to achieve additional coverage.

E. FIRE PUMP

The present available data indicates the pressure as being marginal for the required systems, however it is believed that a design can be achieved without the use of a fire pump. During development of the design, the available pressure will be reevaluated and a fire pump added if required.

4.7 Mechanical – Process Systems

A. DESIGN CRITERIA

The design of the process systems will be in conformance with the design guidelines of the following applicable standards and codes.

1. Building Code of New York State (May 2002 edition)

2. DOE STD-1020-94, Chg. 1, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities. Revised to include reference to ASCE 7-95

3. National Fire Protection Association Standards

   a) No. 50A – Standard for Gaseous Hydrogen Systems at Consumer Sites (1999)
   b) No. 55 – Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks (2003)
   c) No. 318 – Standard for the Protection of Semiconductor Fabrication Facilities (2002)

4. All applicable state and local codes and Authorities Having Jurisdiction (AHJ).

B. PROCESS COOLING WATER SYSTEM

The process cooling water system will include an expansion tank, two recirculation pumps, heat exchangers, high efficiency filters, instrumentation and distribution piping. Process cooling water is supplied to the laboratories at 55degF. The system will be sized for 10degF temperature difference. Chilled water provides the heat rejection source.

The system will have two full-capacity centrifugal distribution pumps. Pumps will be controlled by VFDs to maintain the end-of-loop pressure setpoint. In case of a pump failure, the remaining pump ramps up to full capacity.

One supply and one return connection will be provided for each lab module.

Process cooling water will be distributed in copper piping.

The process cooling water system will be controlled by the facilities management system. Chilled water return flow will be modulated to maintain the PCW supply temperature at the 55degF set point.

Process cooling water pumps will be VFD controlled. Pump speed will be controlled to maintain set point supply and return differential pressure. If one pump fails, the second pump will ramp up to full capacity.

C. DEIONIZED WATER SYSTEM

Deionized water is programmed in only a few of the laboratories. DI water will therefore be produced locally from laboratory cold water by means of local RO/DI and membrane filter systems, dedicated to the respective laboratory. A central DI water system will not be provided for this facility.

D. ATMOSPHERIC GASES

Atmospheric gases (nitrogen, oxygen, helium, and argon) and liquid nitrogen will be distributed locally to the laboratories. Space will be provided in the service galleys for cylinder staging and distribution manifolds.

E. LABORATORY COMPRESSED AIR SYSTEM

The source for the laboratory compressed air will be the site wide 100 PSIG system. The site system is oil free, filtered, clean, and dried to minus 20 degF pressure dew point.

To assure clean, dry compressed air delivery to the laboratories, the incoming service will be provided with a 1 micron coalescing filter to collect moisture and/or particulates originating in the site distribution piping. The filter will be designed to remove all particulates 1 micron and larger, and 100-percent of liquid water. A pressure regulator will be installed downstream of the filter and set for a discharge pressure of 95 PSIG.

Piping for the system will be Type L copper tubing (ASTM B819) with wrought copper fittings and brazed joints, and be routed in the laboratory service galleys. All components including valves shall be cleaned for oxygen service and capped and/or bagged by the manufacturer for delivery to the site for installation. Assembly will be with brazing filler alloy without the use of flux.

Pipe sizing will be based on 5 SCFM per connection with a system simultaneous diversity factor of 20-percent. One connection for chemical fume hoods will be provided for each laboratory module.

F. PROCESS VACUUM SYSTEM

A central process vacuum system will provide vacuum a minimum 18 inches of mercury (vacuum) at all laboratory fume hoods. Vacuum for chamber evacuation will be provided by specialized vacuum pumps furnished with the process equipment.

The process vacuum system will consist of a vacuum receiver and two liquid ring vacuum pumps, each sized for two-thirds of the maximum anticipated demand. Vacuum pumps will produce vacuum at 20 inches of mercury.

Process vacuum piping will be Type L copper (ASTM B88) with solder joint fittings and be routed in the laboratory service galleys.

Pipe sizing will be based on 1.0 SCFM per connection (hood) with a system simultaneous diversity factor of 40-percent. One connection for chemical fume hoods will be provided for each laboratory module.

The vacuum pump system will be controlled automatically. A vacuum pressure sensor located at the vacuum receiver will control automatic on/off operation of each vacuum pump. Once a vacuum pump is started, it will be programmed to run for a minimum adjustable period even though the vacuum set point is met. If set point is not achieved after a pre-determined period, the second vacuum pump will be commanded to start. The pumps will automatically alternate lead-lag position on each start.

G. HOUSE CLEANING VACUUM SYSTEM

A House-cleaning Vacuum System provides a source of vacuum for general house keeping purposes in the cleanroom. A centrally located system will be provided. The system will be sized for simultaneous use by two operators.

H. SPECIALTY CHEMICAL STORAGE AND DISTRIBUTION

A summary of anticipated usage of chemicals that are anticipated in the CFN facility is provided at the end of this section. Chemicals include flammables, water reactives, corrosives, and oxidizers.

All liquid and solid chemicals for process uses in the laboratories will be stored in central chemical area at the rear of the facility, near the loading dock. Chemicals will be transported in approved containers from the chemical stock room to the points of use.

The chemical storerooms will be designed to house approved chemical storage cabinets for each liquid and solid chemical type anticipated in the building. Separate rooms will be provided for corrosive, flammable, oxidizing, and general chemicals. The rooms will be constructed of non-combustible materials. No explosion venting panels will be required.

Each chemical storeroom will be provided with an exhaust ventilation system with a minimum of 1 cfm per square foot of floor area. The system will be designed to operate continuously and exhaust to the outside without recirculation.

Each chemical storeroom will be provided with an automatic sprinkler system. A combination safety shower/eye wash station will be provided in each storeroom, as well as in the receiving area.

Liquid transfer of materials having an NFPA 704 hazard ranking of 3 or 4 will be transferred by safety cans complying with UL 30. Liquid containers exceeding 5 gallons will be transported on a cart or truck. In addition, containers with materials that have a hazard ranking of 3 or 4 per NFPA 704 will be transported on a cart or truck, unless no more than two containers are hand carried in safety containers. Carts and trucks provide a stable base, and have a means of restraining containers. They will also be provided with a speed control device. The cart or truck will be capable of containing a spill from the largest single container being transported. Incompatible materials will not be transported on a cart or tuck at the same time.

Treatment chemicals for closed-loop mechanical systems (e.g., scale and corrosion inhibitors) will be stored in drums or portable totes, depending on the anticipated rate of consumption. These chemicals will be stored in the mechanical room.

I. SPECIALTY GAS STORAGE AND DISTRIBUTION

A summary of the specialty gases that are anticipated for the CFN facility, along with the allowable quantities in storage and use by occupancy type, is provided at the end of this section.

The following specialty gases have been identified as gases that may be used in the facility:

<u>Highly Toxic Gases</u>
Fluorine
Arsine (also flammable)
Dichlorosilane (also pyrophoric)
Phosphine (also pyrophoric)
Diborane (also flammable)

<u>Toxic Gases</u>
Boron Trichloride
Chlorine (also oxidizing)
Ammonia
Hydrogen Sulfide

<u>Pyrophoric Gases</u>
Silane

<u>Flammable Gases</u>
Hydrogen
Methane

<u>Oxidizing Gases</u>
Nitrous Oxide

Definitions of "highly toxic" and "toxic" gases, as defined in the Toxic Gas Ordinance (TGO), are as follows:

"Highly Toxic" (Class I): material that has a median lethal concentration in air of 200 ppm or less by volume, when administered by continuous inhalation of one hour to albino rats weighing between 200 and 300 grams each

"Toxic" (Class II): material that has a median lethal concentration in air of more than 200 ppm but less than 3,000 ppm by volume, under the same conditions

For mixtures, the classification as "highly toxic" or "toxic" depends on the mole fraction of the toxic material in the mixture. For purposes of this analysis, it is assumed that all gases will be pure.

Highly toxic and toxic gases will be stored in gas cabinets located in a central room at the rear of the facility. Cabinets will be contain one active gas cylinder and one inert purge cylinder and will be exhausted directly to atmosphere. Localized exhaust abatement will be provided where required to ensure that exhaust concentration is less than ½ IDLH in the event of a cylinder leak. Where small volume cylinders can be used, or where gases are stored at atmospheric pressure or less in an adsorbed state (such as arsine or phosophine), cylinders will be located at the tools or in adjacent laboratory service galley instead of in a gas cabinet. Alternate gas delivery methods will be further evaluated during detailed design, when the list of anticipated toxic and flammable gases is finalized.

Flammable and pyrophoric gases (hydrogen, methane, and silane) will be dispensed from gas cabinets located on the loading dock, under canopy and behind a secure fence. Cylinders will be located at least 10 feet away from the building in accordance with NFPA 318.

Space will be provided adjacent to the rear loading dock for cylinder staging.

Gas cabinets will be provided with gas detection and automatic shutdown of the gas supply. Cylinders will have high flow shutoff devices installed between the cylinder valve and first control valve. Cabinets will also be sprinklered. Gases will be piped to the process tools in high purity coaxial tubing systems, with the annular space monitored for carrier tube leakage via continuous purge to a toxic gas monitoring detector, then to exhaust. Gases will be piped directly from supply cylinder to tool, i.e., valve manifold boxes will not be used. Cabinets and piping of hazardous materials will meet the requirements of NFPA 318, and the Fire Code of New York State.

A gas management system will be provided to control the specialty gas panels. Gas supply will be automatically shut down upon detection of a leak in the carrier tubing annular space, or upon detection of a leak by the toxic gas monitoring system.

J. TOXIC GAS MONITORING SYSTEM

The toxic gas monitoring will detect hazardous gases at potential points of leakage, and initiate an appropriate alarm and process shutdown response.

The TGM system will include the following: system monitoring panels, calibrated gas sensors, sensor tubing, visual alarm indication (strobe lights) to be distinct from all other alarm systems, audible alarm indication (sirens) to be distinct from all other alarm systems, and outputs to the fire alarm and Building Automation systems.

The toxic gas monitoring system will be located in a secured room at the rear of the building. Samples will be taken at gas cylinder connections, inside gas cabinets, at tool connections, and in chases or service galleys where toxic gases are used.

The TGM system will operate continuously and unattended. Gas sensors will continuously monitor the concentrations of gases for which they are calibrated. If a gas concentration rises to a pre-determined alarm level, area alarms will be initiated, associated equipment will be shutdown, and an alarm will be generated. There will be two alarm stages. The first is a warning alarm indicating that the concentration of a hazardous gas is nearing a dangerous level. The second alarm level is an area evacuation alarm and will also shutdown associated gas distribution equipment. A matrix of alarm levels is provided in the following table, for gases that are anticipated at the CFN facility.

GAS	**TLV/PEL (ppm)**	**IDLH (ppm)**	**LEL (ppm)**	**Alarm 1**	**Alarm 2**
Cl_2	1	10	-	½ TLV	TLV
HCl	5	50	-	½ TLV	TLV
NH_3	50	300	-	½ TLV	TLV
PH_3	0.3	50	-	½ TLV	TLV
B_2H_6	0.1	15	-	½ TLV	TLV
SiH_4	5	50	-	½ TLV	TLV
SiH_2Cl_2	5	50	-	½ TLV	TLV
H_2S	20	100	-	½ TLV	TLV
F_2	0.1	25	-	½ TLV	TLV
AsH_3	0.05	3	-	½ TLV	TLV
BCl_3	5	25	-	½ TLV	TLV

TLV - Threshold Limit Value (ACGIH)
PEL – Personal Exposure Limit (OSHA)
LEL - Lower Explosive Limit
PPM - parts per million
IDLH – Immediately Dangerous to Life and Health (NIOSH)

4.8 Electrical

A. DESIGN CRITERIA

The electrical design will be in accordance with the following codes and guidelines as described within.

1. Building Code of New York State (NYIBC), 2002 Edition.
2. National Electrical Code 2002.
3. National Fire Protection Association (NFPA 101).
4. Energy Code of New York State.
5. Americans with Disabilities Act Accessibility Guideline (ADAAG).
6. Leadership in Energy and Environmental Design (LEED) 2.1.
7. LEED for Labs.

B. SITE UTILITIES

1. Relocation and Demolition of Existing Utilities:

   All existing electrical utilities are routed along the roads at the perimeter of the site. There are no known existing electrical utilities that cross the site or are located below the CFN footprint that require relocation. Portions of abandoned ductbanks if located below the CFN footprint will be demolished.

2. New Utilities:

   a) Power:

      Existing Feeder 600-2 will be taped in existing Manhole MH-71C. A new 6-way SF6 pad mounted switchgear will be located adjacent to Manhole MH-71C and consist of two incoming and four outgoing switches. Feeder 600-2 will be looped in and out of the switchgear via a new 4-way 5" duct bank. Two outgoing switches will be used to serve the two building substations via two 2-way 5" duct banks. The two remaining switches are provided for future use.

      The two transformer substations will each consist of a 15 kV outdoor walk-in fused load interrupter switch, a 13,800-480Y/277 volt 2500 kVA oil filled substation type transformer, and a secondary air terminal section. A 12 way 4" duct bank and 3000A feeder will be extended to each side of the double-ended switchgear located in the main electrical room.

b) Voice/Data:

A 4-way 4” duct dank will be routed from existing Manhole MH-87 located on the south side of Brookhaven Drive to the Main Distribution Frame (MDF) Room. Outside cable will be routed to a yet to be determined location on campus.

c) Fire Alarm:

A 2-way 2” duct dank will be routed from existing Manhole MH-87 located on the south side of Brookhaven Drive to the building fire alarm control panel located in the main entry vestibule.

d) Street Lighting:

No modifications will be made to the existing street lighting system. Refer to the Exterior Lighting paragraph for additional site lighting information.

C. INTERIOR POWER DISTRIBUTION

1. Incoming Supply Distribution Equipment:

One double ended, 3000A, 480Y/277 volt, 3 phase, 4 wire switchgear will be located in the main electrical room. The switchgear will include two pulling sections, two main disconnect sections, one tie section, and two or more distribution sections. The main sections will contain a 3000A 100% rated drawout power air circuit breaker, CT’s, digital meter with communication, and surge suppression equipment. Feeder devices in the distribution sections will also be drawout power air circuit breakers. To reduce the possibility of power disturbances effecting sensitive electronic equipment, one side of the switchgear will serve only lab equipment. The other side of the switchgear will serve non-laboratory loads including mechanical equipment, elevators, lighting, office and corridor receptacles, and other miscellaneous loads.

2. Emergency Power:

a) Emergency power will be obtained from a 350 kW, 480Y/277 volt diesel engine generator located in the service area adjacent to the substations and will be provided with a sound attenuated weatherproof enclosure. Fuel storage will be provided by a 8 hour double walled skid-base fuel storage tank.

b) The generator distribution panel will serve two automatic transfer switches, one for the life safety branch and one for the equipment branch.

c) The life safety branch will serve egress and exit lighting, laboratory hood exhaust fans and make-up units, HVAC controls, and the fire alarm system.

d) The equipment branch will serve one switched light fixture in each lab, the communication system, and the security systems. At this time there are no plans to connect laboratory equipment to the generator. If it is determined that selected lab equipment must be connected to the generator, to prevent equipment damage or loss of an experiment that will takes weeks to reproduce, this equipment would be connected to the equipment branch.

e) Each automatic transfer switch will be provided with an isolation by-pass switch to facility maintenance. A three second pre-transfer signal will be provided with each ATS to prevent out of phase transfers and to initiate time delay relays on large motors to allow staggered starting when connecting to the generator. An automatic generator exerciser will be provided on the life safety ATS.

3. Uninterruptible Power Supply (UPS):

a) A central UPS will not be provided.

b) If uninterruptible power is required for a specific piece of lab equipment, the user may provide point-of-use UPS units.

4. Laboratory Power:

a) Each pair of modules will be provided with a 50A and a 100A 208Y/120 volt panelboard located in the service galley adjacent to the lab. The two panels allow the user to isolate their sensitive equipment from their non-sensitive equipment. The panels for sensitive equipment will be served via a dedicated 15 kVA shielded isolation transformer located in the mechanical room electrical zone above the galley. Each of the five lab blocks will be provided with an 800A, 208Y/120V distribution panel and a 225 kVA shielded isolation transformer located in the mechanical space above the galleys. This distribution panel will sub feed the individual non-sensitive panels at each pair of lab modules. This distribution panel will also serve individual large pieces of lab equipment that would overload the lab panels in the adjacent galley.

b) Each lab panel will be provided with 42 poles and a shunt trip main circuit breaker. The shunt trip feature will be used where local emergency off pushbuttons are required.

c) Within each lab, pre-wired two channel surface mounted aluminum raceway will be provided at bench tops and around the perimeter of the lab and in the service galley. Equipment in the center of the room will be served by overhead ceiling mounted service modules furnished with a variety of receptacles for cord drops to the equipment.

5. House Power:

a) The house distribution system will serve lighting, office and miscellaneous receptacles, mechanical equipment and the elevator.

b) Lighting and receptacle panels will be located centrally in the east and west service galleys to serve instrument labs and offices. A receptacle panel will be located at the north end of the east service galley to serve the spaces at the north end of the building. An additional lighting and receptacle panels will be located at the west end of the cleanroom service galley to serve spaces at the south end of the building.

c) A similar layout of panels will be provide at the second floor except that the panels will be located in the electrical portion of the mechanical room above the service galleys.

d) Mechanical equipment will be served by one or more panels located in each mechanical room. Because most of the motors will be controlled by AFD's, panelboards, in lieu of motor control centers, will be provided. Combination starter/disconnects will be provided at motors not controlled by AFD's.

e) Disconnect switches will be located at all motors.

6. Voltage Utilization:

a) Building lighting - 277 volts.

b) Receptacles - 20 ampere, 120 volt, 2 pole, 3 wire grounding type, and 208 volts with NEMA configurations as required.

c) Motors 1/2 horsepower and larger - 480 volts, three phase.

d) Motors less than 1/2 horsepower - 120 volts.

e) Special equipment/devices will receive voltage and ampere rating as required.

f) Generally, special voltages and frequencies including 220V, 230V, 240V, 380V, DC, 50Hz, 400Hz, 415Hz, etc. will require user provided point-of-use transformers and/or frequency converters. However, because several pieces of equipment are known to require 240V, a special 240V transformer may be provided. This requirement will be reviewed during design development.

7. Voltage Drop:

Voltage drop will be limited to 2% in feeders and 3% in branch circuits.

8. Feeders and Branch Circuits:

a) All conductors will be copper installed in conduit. Conductors #3 and smaller will have THWN insulation. Conductors #2 and larger will have XHHW insulation.
b) Generally, conduit will be electrical metallic tubing with compression fittings. Conduit below grade will be galvanized rigid steel with asphalt coating or schedule 40 PVC. Feeder conduit near the labs and branch circuit conduit within selected labs will be galvanized rigid steel to reduce ELF EMI.
c) All feeder and branch circuit conductors will be provided with color coded insulation.
d) Separate neutral conductors will be provided for each receptacle circuit. Insulation of neutrals will be provided with three colored strips matching their associate phase conductors. Insulation of neutrals serving two or three pole circuits will be solid.
e) All feeders and branch circuits will be provided with a green insulated equipment grounding conductor.
f) All circuits serving laboratory receptacles and equipment will be provided with a green with three yellow strips isolated equipment grounding conductors.
g) The phase, neutral and isolated equipment grounding conductors of circuits serving laboratory receptacles and equipment will be twisted to reduce magnetic fields within the labs.
h) Conductors will be solid for #10 AWG and smaller. Conductors #8 AWG and larger will be stranded. Minimum size conductors will be #12 AWG for branch circuits, #14 AWG, for control wiring and #18 for signal cables.

D. POWER QUALITY

1. The goal is to separate, or isolate, sensitive lab equipment from power disturbing equipment. House loads, include chillers, pumps, fans, elevator, ballasted fixtures, etc., can produce transients, harmonics, voltage sags and a verity of other disturbances on the power distribution system.

2. An opportunity to provide separation at a large scale is available on this project because of the desire to provide a double-ended switchgear. One side will be dedicated to equipment loads in the labs and cleanroom. The other side of the switchgear will serve the house loads. Each substation transformer will provide a significant amount of isolation.

3. Within a given lab, some equipment will be more sensitive than others and some will produce more power disturbances than others. To provide isolation for the more sensitive equipment from the more power disturbing equipment within the same lab or from adjacent labs, two separate panels will be provided at each pair of lab modules. One panel will serve sensitive equipment. The second panel will serve non-sensitive equipment. Each sensitive equipment panel will be fed by a dedicated shielded isolation transformer. The panels for non-sensitive lab equipment will be served by a common shielded isolation transformer.

4. Circuits serving sensitive equipment will be provided with isolated ground receptacles and isolated equipment grounding conductors.

5. Ground fault monitoring will be provided at each lab transformer to provide indication of miswiring of the neutral.

6. Because of the reliability of the utility and the understanding that experiments can be repeated, there are no plans to provide long term outage protection from a generator to any lab equipment. Similarly, there are no plans to provide short term outage protection from a central UPS unit. If necessary, short-term outage protection can be provided by the user by providing point-of-use UPS units.

7. Surge protection devices will be provided at the main switchgear, at each sensitive lab panel and at the distribution panels serving the non-sensitive lab panels.

8. Harmonics will be reduced at the source by providing electronic ballast with a THD less than 10 % and adjustable frequency drives with 3% reactors. The goal is to maintain a current THD at less than 10% and a voltage THD at less than 5% measured at the main switchgear. Transformers serving office and lab receptacles will be K-13 rated.

9. Despite the above measures to protect and isolate sensitive equipment from disturbances, it is not a 100% solution for all equipment. Some equipment may require additional isolation with the use of user provided dedicated point-of-use power conditioners.

E. GROUNDING

1. Grounding Electrode System

   a) The earth grounding electrode system will consist of metal underground water pipes, building steel, foundation reinforcing rods, and a #4/0 grid with 10 foot ground rods around the transformer/generator yard. The grid will also be connected to the grounding conductor run with the campus medium voltage duct bank. The grid and rods will be designed to provide a maximum earth resistance of 5 ohm without the connection to the duct bank ground. All underground connections will be exothermically welded.
   b) A main ground bus located in the main electrical room will serve as the building's single point ground. The grounding electrode conductors, the instrument reference ground, the telecommunication ground, and the lightning protection ground will be connected to the main grounding bus.

2. Power System Grounding:

   a) All power system grounding will be in accordance with the NEC.
   b) The secondary of each 13,800-480Y/277V transformer will be connected to the ground grid.
   c) At the main switchgear, the grounded supply conductor will be connected to the building main ground bus.
   d) The secondary of each 480-208Y/120V transformer will be connected to the nearest building steel and to a local power system ground bus.
   e) A separate green insulated equipment grounding conductor will be provided in all feeders and branch circuits.
   f) Equipment containing filters and power supplies produce small amounts of ground current. Because standard equipment grounding conductors are bonded to enclosures, conduit, supports, etc., these ground currents stray over multiple ground paths through the building back to the transformers. These stray ground currents produce magnetic fields. Therefore, isolated equipment grounding conductors will be provided to as many lab receptacles and equipment as possible. This will allow the ground currents to be contained and routed with the phase and neutral conductors.

3. Instrument Reference Ground:

Each lab module will be provided with an instrument reference ground bus at each lab bench and in each overhead service module. Each instrument reference ground bus will be provided with three screw post ground studs and will be connected directly to a lab instrument reference ground bus located in the service galley. Each lab instrument reference ground bus will be connected directly to the local power system ground bus adjacent to the lab transformers directly above the service galley. Each instrument reference ground system will be insulated from all other grounds except at the single point connection to the power system ground bus.

4. Electrostatic dissipation:

Selected labs will be provided with electrostatic dissipative flooring and/or bench tops. Each section of flooring and bench top will be bonded to equipment grounding conductors in adjacent receptacle outlets.

5. Telecommunication grounding:

Telecommunication grounding will be provided per EIA/TIA 607.

6. Lightning protection:

A complete lightning protection system will be provided. Down conductors will be concealed within the exterior wall in PVC conduit to below grade. One bonding connection to the building main grounding bus will be provided.

7. Cathodic protection:

The soils report will be reviewed for recommendations regarding cathodic protection. Based on other campus projects, it is believed that a cathodic protection system will not be required for buried steel or iron structures or pipelines.

F. ELF EMI (EXTREMELY LOW FREQUENCY ELECTROMAGNETIC INTERFERENCE)

1. To achieve the 1.0 mG environment required in all labs:

   a) Feeders will be routed away from the labs where possible. Those portions of the feeders that are within 20 feet of a lab will be routed in rigid steel conduit.

b) Circuits serving areas other than labs will not be permitted to be routed above lab ceilings or in walls adjacent to labs.

c) Phase, neutral and isolated equipment grounding conductors of each circuit within the lab surface mounted raceways will be twisted.

d) Isolated equipment grounding conductors will be provided in all lab circuits. This will allow low level ground currents to be contained and routed with the phase and neutral conductors reducing net and stray ground currents.

e) Where possible, transformers will be located to minimize the possibility of ground return current passing through lab space.

f) A low-level ground fault will produce significant magnetic fields in two ways. The net current in the supplying circuit will produce a field and each ground return path will also produce a field. To provide early warning of ground fault conditions and to minimize the misuse of the ground as a path for neutral current, a ground fault monitor will be provided on the main bonding jumper at each lab isolation transformer.

2. To achieve the 0.1 mG environment required in selected labs, all methods noted to achieve 1.0 mG above with the following exceptions:

   a) Branch circuit conductors will be twisted and routed in rigid steel conduit directly to outlet boxes. Surface mounted raceways will not be provided.

3. Refer to the Architectural Section for discussion regarding architectural solutions and to the Appendix for an ELF EMI Report prepared by VitaTech Engineering, LLC.

G. VIBRATION ISOLATION

1. The diesel generator will be mounted within a weatherproof, sound attenuated enclosure. The generator will be mounted on spring isolators to an inertia base. The enclosure will be rigidly attached to the same inertia base. This inertia base will than be mounted on a second set of spring isolator support on the foundation pad.

2. Transformers and automatic transfer switches will be mounted on double neoprene pads and connected via flexible steel conduit with at least 90 degrees of bend.

3. No conduit will be routed within or under isolation slabs.

4. Flexible steel conduit will be provided across joints around isolation slabs or walls and to equipment mounted on isolation slabs.

H. EXTERIOR LIGHTING

1. Exterior illumination levels will be as indicated in DOE/IES standards.

2. Parking lots and access drives will be lit by 250 watt metal halide cut-off post-top fixtures mounted on 25 foot aluminum poles.

3. Walkways will be lit by 70 watt metal halide cut-off post-top fixtures mounted on 12 foot aluminum poles.

4. Building mounted exterior lighting will be provided at entrances and exits and at the loading dock, and equipment yard areas.

5. No architectural/façade lighting will be provided.

6. Site lighting will be circuited to building panels and controlled by photocell to provide on/off operation.

I. INTERIOR LIGHTING

1. Lighting design will be accomplished with energy efficient fluorescent lamps and electronic ballasts. Incandescent lamps will be utilized only for accent lighting and in selected labs where low level illumination is required or where electromagnetic interference may occur.

2. Fluorescent lamps for troffers and pendant type fixtures will be T8, 32 watt, 4100°K with a CRI of at least 75.

3. Fluorescent ballasts for T8 lamps shall be electronic type with a ballast factor of 0.85 minimum and total harmonic distortion less than 10 percent.

4. Compact fluorescent lamps will be used in downlights and wallwash fixtures.

5. Exit lights will be LED type.

6. Fluorescent fixtures in labs will be controlled by toggle switches at the entrances. Dimmers will be provided where incandescent lighting in labs is required.

7. Occupancy sensors will be provided in small offices, corridors, restrooms, and in support spaces.

8. Photo sensors will be provided in perimeter offices and in sky lit spaces to de-energize lights when sufficient daylight is present.

9. Footcandle levels will be in accordance with DOE standards where applicable and with the IES Handbook for other spaces:

   a) Laboratories: 50-75 FC general with 75 FC on work surfaces.
   b) Clean rooms: 50-75 FC general with 75 FC on work surfaces.
   c) Offices: 30-50 FC general with 50 FC on work surfaces.
   d) Conference rooms: 30 FC.
   e) Attended support spaces: 30 FC.
   f) Unattended support spaces: 15 FC.
   g) Service Galleys: 50 FC.
   h) Corridors: 10-15 FC.
   i) Restrooms: 10-15 FC general with 30 FC at the mirror/sink area.
   j) Mechanical/electrical equipment rooms: 15 FC.
   k) Telephone/communication rooms: 50 FC.

10. Fixture types are tentatively defined as follows:

   a) Instrument laboratories: Pendant mounted, two lamp, direct/indirect fluorescent fixtures.
   b) Cleanrooms: Cleanroom lighting will be provided with the cleanroom ceiling system with 25 watt T8 lamps recessed in the grid. Yellow, amber and/or red filter lamp sleeves will be provided in photosensitive areas. Fixtures will be connected by Division 16.
   c) Offices: 2x4, 3-lamp, 18-cell parabolic louvered troffers.
   d) Conference rooms: Pendant mounted, two lamp, direct/indirect fluorescent fixtures and/or 2x4, 2-lamp, 12-cell parabolic louvered troffers.
   e) Support spaces: 2x4, 2-lamp, 12-cell parabolic louvered troffers.
   f) Service Galleys: 2-lamp industrial fluorescent with 10% uplight.
   g) Corridors: 1x4, 1-lamp, 9-cell parabolic louvered troffers and/or compact fluorescent downlights.
   h) Restrooms: Recessed fluorescent wall washers mounted along the back and front walls.
   i) Mechanical/electrical equipment rooms: 1-lamp industrial fluorescent with 10% uplight.
   j) Telephone/communication rooms: 2-lamp industrial fluorescent with 10% uplight.

11. Egress and exit lighting will be provided in accordance with NFPA 101 and connected to the life safety branch of the emergency system. Switched emergency lighting, with battery backup connected ahead of the switch, will be provided in laboratories and will be connected to the equipment branch.

J. SPECIAL SYSTEM

1. Laser Safety Door Interlock System:

    a) A laser safety door interlock system will be provided in selected labs and will be designed in accordance with Brookhaven's Environmental, Safety and Health Standard 1.5.3 Interlock Safety for Protection of Personnel and the Brookhaven Laser Safety Officer.

2. Fire Alarm System:

    a) The fire alarm system will be a manual and automatic, multiplex/addressable, supervised fire detection and alarm indicating system.
    b) Manual stations will be located at all building exits and at all exit stairs from Level 2.
    c) Photoelectric area smoke detectors will be located in labs and elevator lobbies, shaft and machine room. Smoke detectors in elevator lobbies, shaft and machine room will initiate elevator recall.
    d) Duct smoke detectors will be provided in air handling systems as required by NFPA 90A.
    e) A high sensitivity smoke detection system (HSSD) will not be provided in the cleanroom area.
    f) Post indicating valves, sprinkler flow and tamper switches, and pre-action and dry-pipe systems will be monitored.
    g) Combination audio/visual and/or visual only devices will be provided throughout the corridor system, in each lab, in each cleanroom bay, and in most rooms other than single person offices. A minimum of two indicating circuits will be provided on each floor with devices connected alternately.
    h) The fire alarm control panel will be located at the main entrance.
    i) Common alarm and trouble signals will be transmitted via dedicated telephone lines to the campus fire alarm system.

3. Ventilation System Emergency Shutdown System (VSES):

    a) The VSES system will provide emergency shutdown of the cleanroom recirculating air-handling units serving the cleanroom.
    b) Emergency pushbutton stations will be located at cleanroom exits.

c) Horns and strobe will be located throughout the cleanroom and the mechanical room serving the cleanroom.

d) Upon activation of an emergency pushbutton, the horns will sound, the strobes will flash, and the recirculating unit will shutdown. The exhaust fans and make-up units will continue to operate.

4. Telecommunication System (Voice, Data and Video):

a) The telecommunication system will consist of pathways and spaces, outside, riser and station cabling and termination hardware. The Government will provide all equipment and instruments.

b) The Main Distribution Frame Room (MDF) is located on Level 1 adjacent to the main lobby. 4 – 4” conduits will be routed to Manhole MH-87 on the south side of Brookhaven Drive.

c) Intermediate Distribution Frame Rooms (IDF) are located in the southeast and southwest corners of Level 1. On Level 2, IDF’s are located in the southwest and northeast corners.

d) MDF/IDF’s are located such that no station cable run will exceed 300 feet.

e) Cable tray will be provided in all corridors and service galleys on Levels 1 and 2. The cable tray will be sized to accommodate riser and station cabling.

f) Conduit will be provided between the cable tray and each outlet or surface mounted raceway.

g) One outlet will be provided at each workstation.

h) In labs, two-channel surface mounted aluminum raceway will be provided at bench tops and around the perimeter. Conduit will be provided between the top channel and the cable tray. Outlets will be provided at an average density of one outlet per module. Additional outlets will be provided in each overhead service module.

i) Each outlet will consist of one Category 5 voice jack, one Category 5 data jack and provisions for two future fiber optic connectors.

j) Voice and data riser cabling will be provided from the MDF to each IDF. Voice riser cables will be multi unshielded twisted pairs, 24 gauge, solid copper and terminated on the terminal block in each closet. Data riser cabling will be multi unshielded twisted pairs, 24 gauge, solid copper and/or 12 strand 62.5/125 multimode optical fiber terminated at each end in a patch panel with a type SC connector. Voice terminal block will be mounted on plywood. Patch panels will be mounted in 19” equipment racks.

k) Station cabling from each outlet will consist of one 4-pair Category 5 voice cables and one 4-pair Category 5 data cables and terminated at the devices and on the telephone terminal blocks and data patch panels. Cables will be labeled at each device, terminal block and patch panel.

5. Security System:

a) At this time, the security system has not been defined. The scope will be developed during the design development phase. The following is offered for estimating purposes only:
b) The security system will consist of an access control system. Identification cards will be equal to, or compatible with, the current Brookhaven standard.
c) Card readers will be located at each building entrance and at each lab entrance.
d) The card reader system central control panel will be located in the Main Distribution Frame Room and will communicate with the campus security system. Recording of events will take place at the central control panel and at the campus security station.
e) The card reader system will have the capacity and capability for future expansion via expansion cards and software.

6. Public Address:

A public address system will not be provided.

7. Clock System:

A clock system will not be provided.

5.0 ATTACHMENTS

5.1 CFN Equipment List

Note: The CFN Lab Equipment and Utility Requirements are contained in the Room Data Sheets and Lab Equipment Plans Book submitted by HDR as part of the 100% Title I Report.

5.1 CFN Equipment List (with Room Location in the CFN)

5.1.1 WBS 1.2.1 Nanopatterning

JBX 9300 FS Electron Beam Lithography Unit – 1L47, NP-2
FEI Nova 200 Focused Ion Beam System – 1L45, NP-9
Molecular imprints Imprio 55 Nanoimprinter – 1L46, NP-10
Trion Phantom III Deep Silicon Etch System – 1L43, NP-13
EVG 101 Photoresist Development Station – 1L46, NP-1

5.1.2 WBS 1.2.2 Ultrafast Optical Sources

0.01-2.5 kHz 4 mJ nm Laser System – 1L01, UF-1, UF-2
Nonlinear Frequency Synthesis Setups – 1L01, UF-3, UF-4
Surface Science Experimental Station – 1L01, UF-5
Vacuum Chambers – 1L01, UF-6, UF-7
Turbo-Pump Station – 1L01, UF-11, UF-16
Ultrafast System – 1L01, UF-8
Power Amplifier – 1L01, UF-9
Monochromator – 1L01, UF-17
Streak Camera – 1L01, UF-10
Optical Table & Legs – 1L01, UF-12
3GHz Digital Oscilloscope – 1L01, UF-13
500 MHz Oscilloscope – 1L01, UF-14
Vacuum Compressor & XUV/SXR Chamber – 1L01, UF-15

5.1.3 WBS 1.2.3 Electron Microscopy

STEM (Nion UltraSTEM200) – 1L30, EM-4

5.1.4 WBS 1.2.4 Materials Synthesis

Experimental X-Ray Diffractometer (Tabletop) – 1L10, MS-1
Molecular Beam Epitaxy (MBE) – 1L09, MS-2
Glove Boxes (2) – 1L05/07, MS-17
Thermal Measurement Lab – 1L16, MS-24
NMR Spectrometer – Bruker – 1L10, MS-72
Vacuum Evaporator – 1L17, MS-59
PPMS (Physical Property Measurement System) – 1L16, MS-60
Vibrating Sample Magnetometer – 1L16, MS-80

5.1.5 WBS 1.2.5 Proximal Probes

Low Energy Electron Microscopy (LEEM) – 1L38, PP-5
UHV Variable Temperature Scanning Tunneling Microscope – 1L38, PP-1
UHV Low Temperature Scanning Tunneling Microscope – 1L38, PP-4
Environmental Combination STM/AFM – 1L34, PP-2
UHV Nanoprobe – 1L38, PP-6
NSOM/SPM – 1L34, PP-3
Combination Optical Microscope and UltraObjective SPM – 1L33, PP-7
Raman Spectroscopy – 1L33, PP-9
UV-VIS Raman Microscope – 1L-33, PP-10
FT-IR/FT-Raman/IR Microscope – 1L33, PP-11
UV/VIS/NIR Spectrometer – 1L39, PP-13

5.1.6 WBS 1.2.6 Theory & Computation

Computer System – 2L01, TC-1

5.1.7 WBS 1.2.7 CFN Endstations at NSLS (located in existing NSLS building)

165mm CCD Detector System for X-ray Diffraction – LS-1
Wide Angle Detector – LS-2
Fast Detector – LS-3
High Resolution GID Detector – LS-4
Optical Table 1 – LS-5
Optical Table 2 – LS-6
Flight Tube – LS-7
In-vacuum SAXS/GISAXS Sample Chamber – LS-8
Motion Control Electronics – LS-9
Vacuum System – LS-10